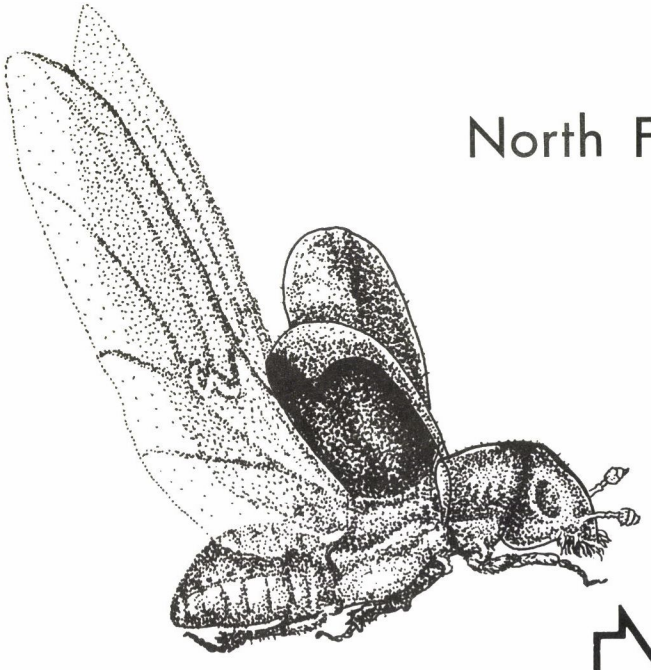
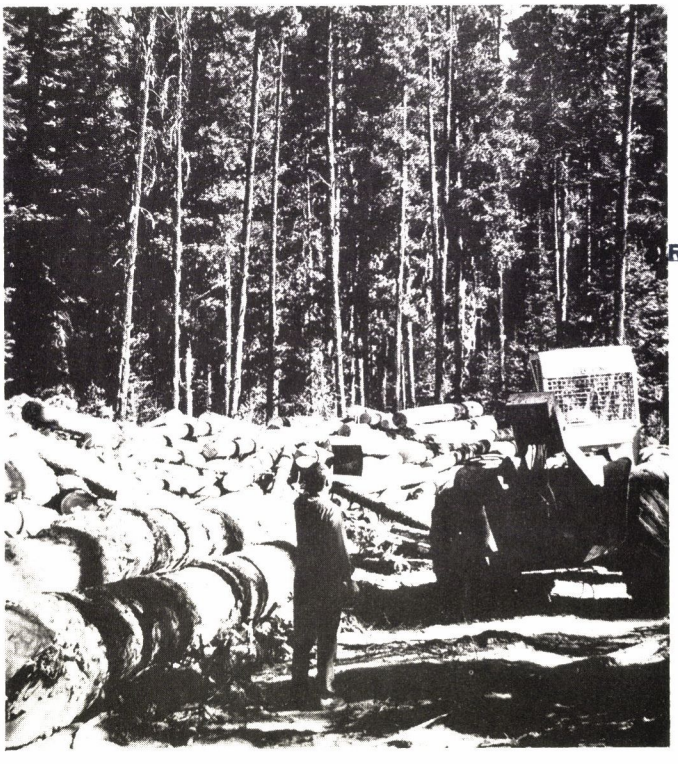
SB761
U7N6
#74-7

REPORT NO. 74-7

# EVALUATION OF THE DOUGLAS-FIR BEETLE INFESTATION

## North Fork Clearwater River Drainage Northern Idaho, 1970-1973





LIBRARY
AUG 23 1974
ROCKY MOUNTAIN STATION

U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE • NORTHERN REGION
Division of State and Private Forestry
Missoula, Mt. 59801

Explanation of cover photos:

Top right: Stand infested with Douglas-fir beetle

Lower right: Ground evaluation of beetle-infested stands along Dworshak Reservoir, North Fork Clearwater River drainage

Lower left: Salvage logging of infested trees

# EVALUATION OF THE DOUGLAS-FIR BEETLE INFESTATION NORTH FORK CLEARWATER RIVER DRAINAGE, NORTHERN IDAHO, 1970-73

by

M. D. McGregor [1], M. M. Furniss [2], W. E. Bousfield [1], D. P. Almas [3], Paul J. Gravelle [4], and R. D. Oakes [5]

## ABSTRACT

An outbreak of Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopk., began in 1969 in the North Fork Clearwater River drainage in northern Idaho. This infestation probably resulted from trees felled during clearing for the Dworshak Reservoir, from ice and snow breakage which occurred during the winter of 1968-69 in stands adjacent to the proposed reservoir, and an abundance of mature and overmature Douglas-fir within the drainage. The outbreak reached epidemic proportions in 1970, but was not detected until 1971.

To determine impact of this insect on Douglas-fir stands within the area of infestation and establish a base from which to conduct salvage logging, a two-stage survey using aerial photography followed by a ground cruise was conducted in 1971, 1972, and 1973. Area surveyed varied from 288,000 acres in 1971 to 494,000 in 1972, and was reduced to 287,000 acres in 1973.

The 1971 survey estimated that 174,164 trees were killed during the 2-year period 1970-71, resulting in a volume loss of 85.8 MMBF of Douglas-fir sawtimber on 288,000 acres. In 1972, an estimated 46,844 trees were killed with a volume loss of about 17.8 MMBF on 494,000 acres. In 1973, the survey estimated that 8,141 trees were killed with a volume loss of 4.2 MMBF of merchantable timber on 287,000 acres. The infestation has been declining since 1971.

---

1/ Entomologist, Environmental Services, Division State and Priv. Forestry, USDA, Forest Service, Missoula, Montana.

2/ Principal Entomologist, Intermountain Forest and Range Extp. Sta., USDA, Forest Service, Moscow, Idaho.

3/ Branch Chief, Private Forestry, Idaho Dept. of Public Lands, Coeur d'Alene, Idaho.

4/ Forester, Potlatch Corporation, Lewiston, Idaho.

5/ Biological Technician, Intermountain Forest and Range Expt. Sta., USDA, Forest Service, Moscow, Idaho.

## INTRODUCTION

Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopk., is the most serious bark beetle enemy of Douglas-fir, *Pseudotsuga menziesii* (Mirb.) Franco, in the Northern Rocky Mountain Region. Past outbreaks have been attributed to catastrophic disturbances such as windthrow, trees damaged by snow and ice, and stressed by drought. In the Clearwater River drainage, the last outbreak occurred during 1950-52 (Evenden, 1952), killing approximately 7.6 percent of the merchantable Douglas-fir stand.

The present outbreak in the North Fork Clearwater River drainage was first detected and its severity reported in the spring of 1971 when trees attacked in 1970 began to fade. 6/ An aerial survey was conducted to map locations of groups of infested trees. This survey showed the infestation covered approximately 288,000 acres of forest lands of mixed ownership administered by the State of Idaho, Potlatch Corporation, Bureau of Land Management, Diamond International Company, U.S. Army Corps of Engineers, and the Clearwater and St. Joe National Forests (Fig. 1). In 1970, Douglas-fir beetle populations increased to epidemic levels apparently due to presence of trees felled during clearing of Dworshak Reservoir and in trees top-broken by heavy snow and ice during the winter of 1969-70 (Ciesla et al, 1971). Also, it was observed that some infested trees were only 80 to 90 years old -- younger than had been observed in prior outbreaks (Furniss et al., in prep.).

Because of the expanse of the outbreak and the potential for additional damage, members of the Northern Rocky Mountain Pest Action Council undertook a cooperative survey to determine current losses and the potential for additional damage. A two-stage survey using aerial photography followed by a ground cruise was conducted in 1971 (Ciesla et al., 1971) and again in 1972 (McGregor et al., 1972; McGregor, 1973).

In 1973 the North Fork Clearwater River infestation was surveyed again with the primary objectives being to:

1. Refine and improve methods for measuring losses by the Douglas-fir beetle in the Northern Rocky Mountains.

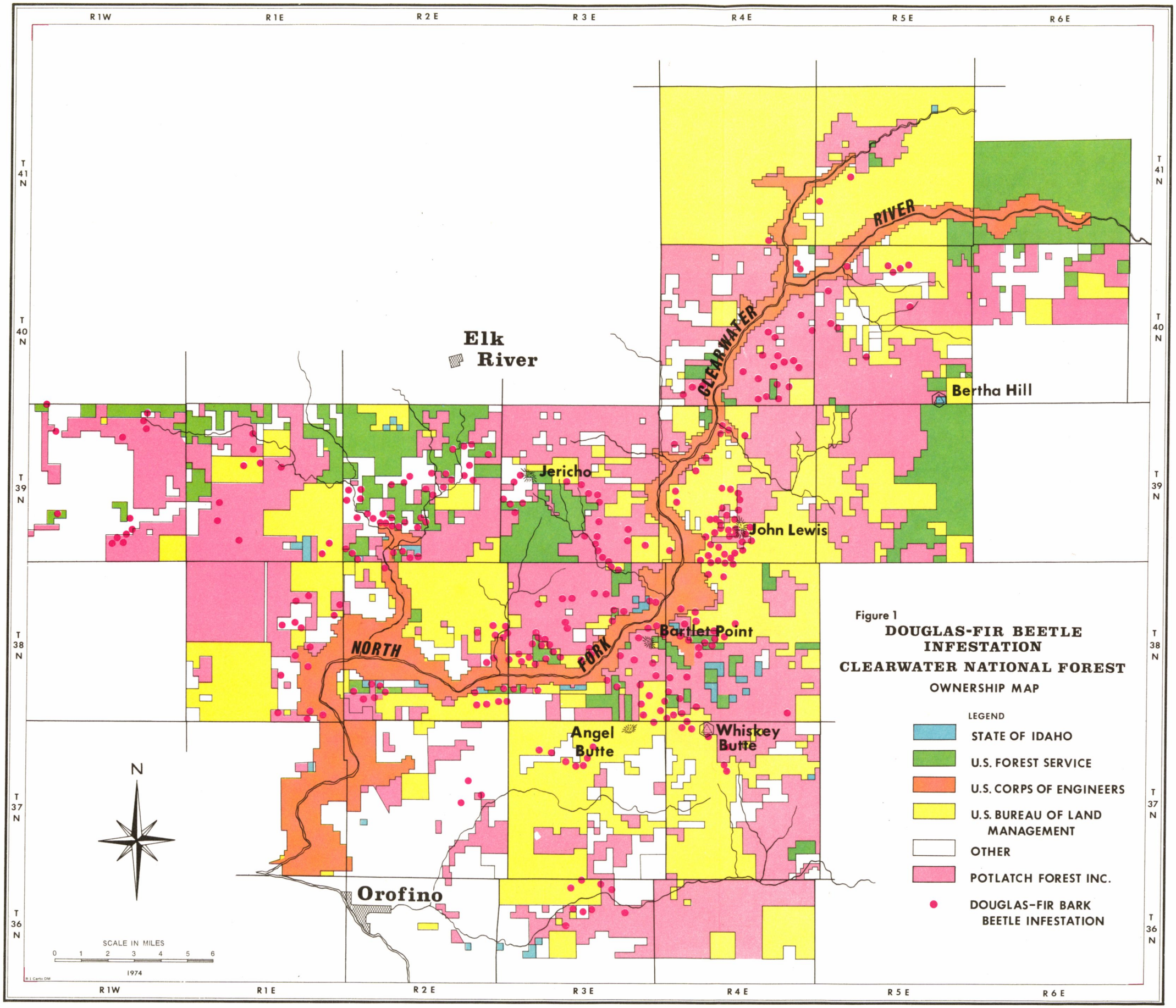
2. Estimate number of trees killed by the Douglas-fir beetle and volume loss in 1973.

3. Determine infestation trend.

Results of the 1973 damage survey are reported here.

---

6/ Communication from M. O. Koppang, Clearwater-Potlatch Timber Protective Association, Orofino, Idaho, July 1, 1971.


R1W
R1E
R2E
R3E
R4E
R5E
R6E
T 41 N
T 40 N
T 39 N
T 38 N
T 37 N
T 36 N
Elk River
CLEARWATER RIVER
NORTH FORK
Bertha Hill
Jericho
John Lewis
Bartlett Point
Angel Butte
Whiskey Butte
Orofino
N
SCALE IN MILES
0 1 2 3 4 5 6
1974
R 1 Carto DM
Figure 1
DOUGLAS-FIR BEETLE INFESTATION
CLEARWATER NATIONAL FOREST
OWNERSHIP MAP
LEGEND
STATE OF IDAHO
U.S. FOREST SERVICE
U.S. CORPS OF ENGINEERS
U.S. BUREAU OF LAND MANAGEMENT
OTHER
POTLATCH FOREST INC.
DOUGLAS-FIR BARK BEETLE INFESTATION

## SURVEY METHODS

Damage estimates.--Prior to photography in 1973, the zone of infestation was predetermined by mapping groups of faders from the air in late June. In late July a two-stage survey, consisting of aerial photo samples corrected by a ground sample of selected plots was conducted. In late July, a series of 186 aerial stereo pairs with 60 percent overlap were taken at a scale of 1:8000 on a 2- by 2-mile grid pattern over the 287,366-acre infestation by the Division of Engineering, U.S. Forest Service, Missoula, Montana. Photos were taken on a 9-inch format with a Zeiss-RMKA 15-23 aerial camera equipped with a 6-inch focal length lens and an anti-vignetting color filter. True color Ektachrome MS Aerographic 2448 Estar Base Film was used. 7/ One-hundred-acre plots, 20 by 50 chains, were systematically delineated with a template in the stereo overlap portion of each photo pair. Photo interpreters examined each photo plot with an Old Delft scanning stereoscope and the faded Douglas-fir crowns were counted in each 100-acre block (Fig. 2). Care was taken to separate Douglas-fir mortality from western white pine, (*Pinus monticola* Dougl.,) killed by mountain pine beetle, *Dendroctonus ponderosae* Hopk., or white pine blister rust, *Cronartium ribicola* J. C. Fisher; and grand fir, (*Abies grandis* Lindl.,) killed by fir engraver beetle, *Scolytus ventralis* Lec.

Thirty of the 186 photo plots were selected for ground cruising. Plots were selected with the computer program PPSORT (Stage, 1971) which selects on a probability proportional to the number of Douglas-fir faders observed in each 100-acre plot. This selection concentrates sampling in areas of highest beetle activity and reduces sampling in subepidemic or endemic areas. Bias is eliminated by including the probability of plot selection in the data analysis.

After faders were counted on each 100-acre block, a dot-grid was placed over each block and the acres of commercial-sized forests, young stands, non-forested, logged, spruce type, and water were determined for each block. This stratification eliminated nonhost types as well as nonsusceptible age classes, such as pole size and reproduction size stands and nonstocked areas from the survey.

The scale of each photo was determined on the ground to correct scale differences due to elevation of the aircraft during flight, and provide correct acreage figures.

On each ground cruise plot, 1/2-chain wide cruise lines were run lengthwise, beginning 1-1/4 chains from plot corner. Cruise lines were 3½ chains apart; their number varied per block depending on block size.

---

7/ Mention of commercial trade names is for convenience only and does not imply endorsement by the U.S. Department of Agriculture.

Figure 2.--Counting Douglas-fir beetle faders on photo plots.

On each cruise line, diameter at breast height (d.b.h.) and total height were measured for each attacked Douglas-fir tree 8 inches d.b.h. and larger. Trees down to 8 inches d.b.h. were measured because some trees in this d.b.h. size were found to be infested in past outbreaks. Each tree was then examined for attack success and year of mortality.

Photo counts were compared with ground survey data from each block surveyed to provide current estimates of infestation levels and volume losses for 1972-73. Estimates of the total tree population were obtained by dividing the ground truth by the probability by which it was selected and then incorporating output from the PPSORT program to measure population variance.

Photo interpretation data were correlated with tree and volume loss estimates from the ground survey, and a correlation coefficient "r" was computed. Two variables, number of trees and volume estimates, were used as the dependent variable (Y) and the photo count of discolored trees was the independent variable (X) in the regression analysis.

Population sampling.--Fifteen groups of infested trees were selected for brood sampling in 1973. These groups were located at Meadow Ridge, along Dworshak Reservoir, Elk Falls, North Fork Dicks Creek, Buck Butte, Laddis Creek, Swamp Creek, and Cole Creek. Infested groups were sampled during September and October each year. When sampling was done in 1973 many of the 1973-attacked trees had already faded due to severe summer drought.

Groups of infested trees were not randomly selected but were selected according to their distribution within the infestation; that is, we attempted to obtain a degree of geographic representation within the infestation. Although lack of randomness limits inference from the data, we were forced to this course by practical consideration such as accessibility of infested groups and time available.

Infested groups were delineated on the ground by traversing the edge of each group. Within each infested group, all attacked trees were categorized as being (1) successfully attacked (containing brood) or (2) unsuccessfully attacked (lacking brood). Bark samples were then removed from 2 to 10 successfully attacked trees per group (Fig. 3). In each group, two bark samples were removed from between 9 and 15 feet up the infested bole as recommended by Furniss (1962b) from 2 to 10 successfully attacked trees using a one-tenth square foot bark punch. In each bark sample, the number of gallery starts (attacks), inches of parent gallery, over-wintering brood, and natural enemies (parasites and predators) were counted.

## RESULTS

Damage estimates.--Extensive losses have occurred during the 4-year period 1970-73 in the North Fork Clearwater River drainage (Table 1). Surveys estimate that in excess of 248,000 trees containing 111 MMBF were killed during this period. In 1971, the survey disclosed that 174,164 trees were killed during the 2-year period 1970-71, resulting in a volume loss of approximately 85.8 MMBF of merchantable Douglas-fir on 288,000 acres. In 1972, an estimated 46,844 trees were killed with a volume loss of about 17.8 MMBF on approximately 494,000 acres. Data from the 1973 survey indicate that about 8,141 trees containing 4.2 MMBF of merchantable Douglas-fir were killed. Each infested tree contained an average volume of 516 board feet.

In the area (287,000 acres) included in the 1973 survey, 67 percent was forested (including Douglas-fir), 21 percent had been logged, 6 percent was on forested, 2 percent was spruce type, and water covered 2 percent of the area. This shows that the area containing Douglas-fir type occurred only on about 193,684 acres.

The average d.b.h. of attacked trees was 20 inches in 1970, 16 inches in 1971, 18 inches in 1972, and 20 inches in 1973.

From our inventory of infested groups we know that beetles killed larger trees more frequently than smaller trees. Larger trees are usually

Figure 3.--Sampling Douglas-fir beetle broods, North Fork Clearwater River, Idaho, 1973.

dominant and inherently more attractive. Possibly the quantity and quality of odors emitted by them is responsible for their attractiveness.

Although larger trees may be more resistant than smaller ones to a particular attack density, the intense aggregation of large numbers of beetles could result in more of them being killed than their suppressed neighbors (Furniss et al, in prep.). We also know that smaller trees are attacked less densely than larger ones. Also, as larger trees are killed and the stand is opened up, stems of smaller trees are exposed to more sunlight and this may be less conducive to beetle attack. For example, Douglas-fir beetles tend to concentrate their attacks on the shaded side of sun-exposed windthrow trees (Furniss 1962a).

In 1973, trees successfully attacked averaged 115 years old (range 80 to 183) and averaged 21.1 inches d.b.h. (range 15.1 to 29.3). Unsuccessfully attacked trees averaged 16 inches d.b.h. (range 11 to 24) and the average age was 121 years (range 80 to 150) in 1971. In 1972, unsuccessfully attacked trees averaged 18 inches d.b.h. (range 16 to 25) and the average age was 119 years

Table 1.--Estimates of trees and volume killed by the Douglas-fir beetle, North Fork Clearwater River, Idaho, 1970-1973.

| Item | Year of Attack | | | |
|---|---|---|---|---|
| | 1970 1/ | 1971 1/ | 1972 2/ | 1973 3/ |
| Trees/acre | 0.237 ± .086 | 0.368 ± .108 | 0.133 ± .033 | 0.028 ± .007 |
| Total trees | 68,515 ± 24,734 | 106,099 ± 31,087 | 66,021 ± 16,564 | 8,141 ± 22.23 |
| Vol./acre (MBF) | 123.7 ± 40.9 | 177.7 ± 35.3 | 49.8 ± 16.0 | 14.62 ± 3.23 |
| Total volume (MMBF) | 34,630 ± 10,465 | 51,195 ± 10,290 | 24,633 ± 7,915 | 4,202,110 ± 1,080,410 |
| Av. vol./infested tree (bd. ft.) | 520 | 482 | 374 | 516 |

1/ Data from 1971 survey.

2/ Data from 1972 survey.

3/ Data from 1973 survey.

(range 91 to 148). In 1973, unsuccessfully attacked trees averaged 16 inches d.b.h. (range 11 to 24) and the average age was 115 years (range 80 to 183). In 1971, 31 percent of the trees were attacked unsuccessfully. This increased to 59 percent in 1972, and was 57 percent in 1973. Data obtained during population sampling during the 3 years showed the ratio of unsuccessful to trees successfully attacked was 1:1 in 1971, or 50 percent; 1:0.5 in 1972, or 67 percent; and 1:0.5 in 1973 (67 percent). Estimates of Douglas-fir beetle pitchouts (attacked unsuccessfully) trees during this infestation are shown in Table 2.

Correlation of ground truth data with photo counts was stronger when the infestation was at its peak in 1971 than in 1973. As the infestation began subsiding and groups of infested trees became more widely scattered, it was more difficult to obtain a correlation between the number of trees counted on the photo block with those tallied on respective ground plots. Low numbers and zero counts increase the standard error when using probability sampling.

Table 2.--Estimated Douglas-fir beetle unsuccessfully attacked trees North Fork Clearwater River infestation, 1972-1973.

| Item | 1972 | 1973 |
|---|---|---|
| Trees/acre | 0.246 ± .084 | 0.056 ± .020 |
| Total trees | 121,909 ± 41,932 | 16,166 ± 5,796 |
| Volume/acre (bd. ft.) | 74.3 ± 24.3 | 25.4 ± 11.0 |
| Total volume | 36,714,000 ± 12,525,100 | 7,308,650 ± 3,156,000 |
| Av. vol./tree (bd. ft.) | 302 | 454 |

The sequence of regression formulas also shows that the volume per infested tree is lower in 1973 than at the beginning of the infestation, as the coefficient for volume per tree count had declined since 1971 (Table 3).

A sharp buildup in number of infested groups occurred along the Dworshak Reservoir in 1973 (Fig. 4). These trees occurred mainly from Dicks Creek up reservoir to Weitas Creek. Infested groups varied from 1 to 27 trees per group, and were usually within one-fourth mile of the water's edge, indicating some relationship to the existence of the reservoir, which has been filled for only 2 years. Also, the majority of these groups occurred on drier sites where trees may be particularly stressed from drought of the type experienced in 1973.

Table 3.--Regression equation for predicting numbers of infested trees and volume losses, Douglas-fir beetle survey, North Fork Clearwater River, Idaho, 1971-1973.

| PI [1] | Y | Regression equation Y = a + bx | F Ratio f slope | Correlation Coefficient r |
|---|---|---|---|---|
| | | 1971 SURVEY [2] | | |
| WMC | 1970 tree | Y= 14.67 + 1.675X | 45.59* | 0.815 |
| WMC | 1970 volume | Y=4626.77 + 761.301X | 144.79* | .926 |
| WEB | 1970 tree | Y= 8.84 + 1.829X | 46.47* | .813 |
| WEB | 1970 volume | Y=1217.33 +1182.13X | 122.016* | .914 |
| | | 1972 SURVEY [3] | | |
| WEB | 1971 tree | Y= -17.4 + 3.17X | 24.43* | .725 |
| WEB | 1971 volume | Y=5092.32 + 515.65X | 5.17* | .456 |
| | | 1973 SURVEY [4] | | |
| MDM | 1972 trees | Y= .142+ .349X | 17.54* | .621 |
| MDM | 1972 volume | Y= 57.57 + 362.58X | 12.38* | .554 |

1/ PI = Photo Interpreter; WMC = W. M. Ciesla; WEB = W. E. Bousfield; MDM = M. D. McGregor
2/ Based on 288,000 acres
3/ Based on 493,080 acres
4/ Based on 287,369 acres
* Significant at 95 percent level.

Trees suspected of being attacked by Douglas-fir beetle in these groups were felled, and were found to be previously attacked in the upper one-third of the crown by *Scolytus tsugae* (Sw.) and/or the California flat-headed borer, *Melanophila drummondi* Kby. Some trees were attacked their entire length by *S. tsugae* while others were top-killed by *S. tsugae*, then attacked by *M. drummondi* in the lower bole. Other faders examined had been attacked by Douglas-fir beetles in the lower two-thirds of the stem after being top killed by *S. tsugae* and some were only infested with *D. pseudotsugae*. We believe that the prominence of traditionally secondary beetles such as *S. tsugae* and *M. drummondi* was due to the severe drought that stressed infested trees.

Brood sampling.--A summary of groups of trees sampled by year is presented in Table 4. It became necessary to inventory more groups to obtain reliable trend prediction data as the outbreak declined.

Figure 4.--Douglas-fir beetle faders along Dworshak Reservoir, 1973.

Table 4.--Summary of Douglas-fir beetle infested groups inventoried for trend prediction, North Fork Clearwater River drainage, 1971-73.

| Year | Groups of trees sampled | Number of trees inventoried or sampled | Average number of trees/group |
|---|---|---|---|
| 1971 | 3 | 475 | 158 |
| 1972 | 11 | 873 | 79 |
| 1973 | 15 | 232 | 21 |
| TOTAL | 29 | 1,580 | |

Of the 232 trees sampled in 1973, 67 percent were attacked unsuccessfully. Acreage infested per group ranged from 0.11 acre to 6.10 acres, averaging 1.10 acres (Table 5).

Table 5.--Summary of Douglas-fir beetle sample groups, North Fork Clearwater River drainage, Idaho, 1973.

| Group No. | Group dimensions (L) feet | (W) feet | Area acres | Elevation feet | Number of trees |
|---|---|---|---|---|---|
| 1 | 460 - | 330 | 3.48 | 2990 | 7 |
| 2 | 250 - | 150 | .86 | 3005 | 10 |
| 3 | 155 - | 30 | .11 | 1710 | 5 |
| 4 | 296 - | 60 | .41 | 1940 | 27 |
| 5 | 125 - | 110 | .31 | 1930 | 12 |
| 6 | 325 - | 130 | .97 | 1905 | 15 |
| 7 | 225 - | 100 | .52 | 1710 | 15 |
| 8 | 120 - | 70 | .19 | 1730 | 6 |
| 9 | 300 - | 150 | 1.03 | 1650 | 14 |
| 10 | 150 - | 125 | .43 | 1700 | 21 |
| 11 | 175 - | 150 | .60 | 3650 | 20 |
| 12 | 200 - | 100 | .46 | 3380 | 17 |
| 13 | 140 - | 80 | .26 | 3380 | 11 |
| 14 | 625 - | 425 | 6.10 | 3670 | 117 |
| 15 | 200 - | 175 | .80 | 2700 | 29 |
| Av./group | 249 | 145 | 1.10 | 2470 | 21 |

In 1973 bark punch data (242 samples) showed gallery starts ranged from 2 to 29, average 9.5 (range 2 to 9 per square foot); and inches of parent gallery from 14.8 to 155.0, average 59.7 (range 15 to 155 per square foot). This showed that the number of attacking parent beetles averaged 19 per square foot (range 4 to 58). Douglas-fir beetle brood in these samples averaged 14.3 per square foot (range 0 to 56). This gave a brood/parent ratio in the fall of 0.82:1 (Table 6).

Table 6.--Summary of Douglas-fir beetle bark punch data, North Fork Clearwater River drainage, Idaho, 1973.

| | | Number/square foot | | | |
|---|---|---|---|---|---|
| | | Galleries | | Douglas-fir beetle brood | Brood/ parent ratio |
| Group | No. samples | No. starts | Total length (inches) | (new adults) | |
| 1 | 8 | 3 | 40.4 | - | - |
| 2 | 4 | 2 | 14.8 | - | - |
| 3 | 10 | 9 | 60.2 | 11 | .61:0 |
| 4 | 20 | 11 | 46.9 | 19 | .86:0 |
| 5 | 20 | 8 | 69.9 | 24 | .50:1 |
| 6 | 20 | 12 | 97.8 | 37 | .54:1 |
| 7 | 8 | 4 | 74.3 | 26 | .25:3 |
| 8 | 12 | 13 | 71.8 | 21 | .81:0 |
| 9 | 20 | 28 | 116.4 | 56 | .00:1 |
| 10 | 20 | 26 | 107.0 | 26 | .50:0 |
| 11 | 20 | 29 | 145.4 | 10 | .17:0 |
| 12 | 20 | 24 | 106.9 | 31 | .65:0 |
| 13 | 20 | 22 | 155.0 | 24 | .55:0 |
| 14 | 20 | 15 | 128.4 | 40 | .33:1 |
| 15 | 20 | 24 | 150.1 | 21 | .44:0 |
| Total | 242 | 15.3 | 52.2 | 14.3 | 0.82:1 |
| | | - - - -(Average per square foot)- - - | | | |

- indicates no brood

Natural enemies were generally few in number. Counts varied from 0 to 32 per square foot, average 0.34 per square foot. The most prevalent parasite was the wasp, *Coeloides brunneri* Vier., followed by two predators, a fly, *Medetera* sp., and an Ostomid beetle, *Temnochila chlorodia* (Mann.). Clerids occurred on bark samples in 1971 and 1972, but not in 1973 (Table 7).

## DISCUSSION

The epidemic Douglas-fir beetle infestation that has been active the past 4 years continued to decline in 1973 as predicted (McGregor et al., 1972, Furniss et al., in prep.) 8/

Several factors that verify the decline of the outbreak are:

1. The decrease in number of successfully attacked trees from 1971 through 1973

2. The high rate of unsuccessfully attacked trees

3. Decrease in number of trees per group

4. The population index (brood to parent) being 0.82:1.

The estimated volume of Douglas-fir killed during 1971-73 was approximately 248,000 trees containing a 111 MM board foot volume, or about 16.5 percent of the merchantable Douglas-fir stands surveyed. The damage trend during these years is shown in Fig. 5. The 1971 damage was estimated again in 1972, and the 1972 damage was estimated again in 1973, but was less in the latter 2 years than measured in the 2 previous years. We believe two reasons can account for these differences: (1) Salvage logging of more than 40 million board feet of Douglas-fir which removed several thousand beetle-killed trees that would have been recorded on survey plots; (2) Some trees attacked in 1971 and 1972 may have faded earlier than normal and lost their needles prior to the 1972 and 1973 surveys; consequently, such trees would not have been tallied as 1971 and 1972 attacks.

A marked increase in the proportion of unsuccessfully attacked trees occurred from 1971 to 1972 (31 percent to 59 percent). This high level continued through 1973. Reasons for this increase may be (1) many of the more susceptible trees were killed during 1971 when beetle populations were high leaving fewer each successive year, and (2) the weather was more favorable to tree growth during 1971 and 1972 and increased moisture is associated with increased tree resistance to Douglas-fir beetle (Rudinsky 1966). However, it is very likely that we might experience a marked increase in number of infested trees in

---

8/ 1630 Memorandum by M. M. Furniss, February 21, 1973. State and Priv. Forestry files, Missoula, Montana.

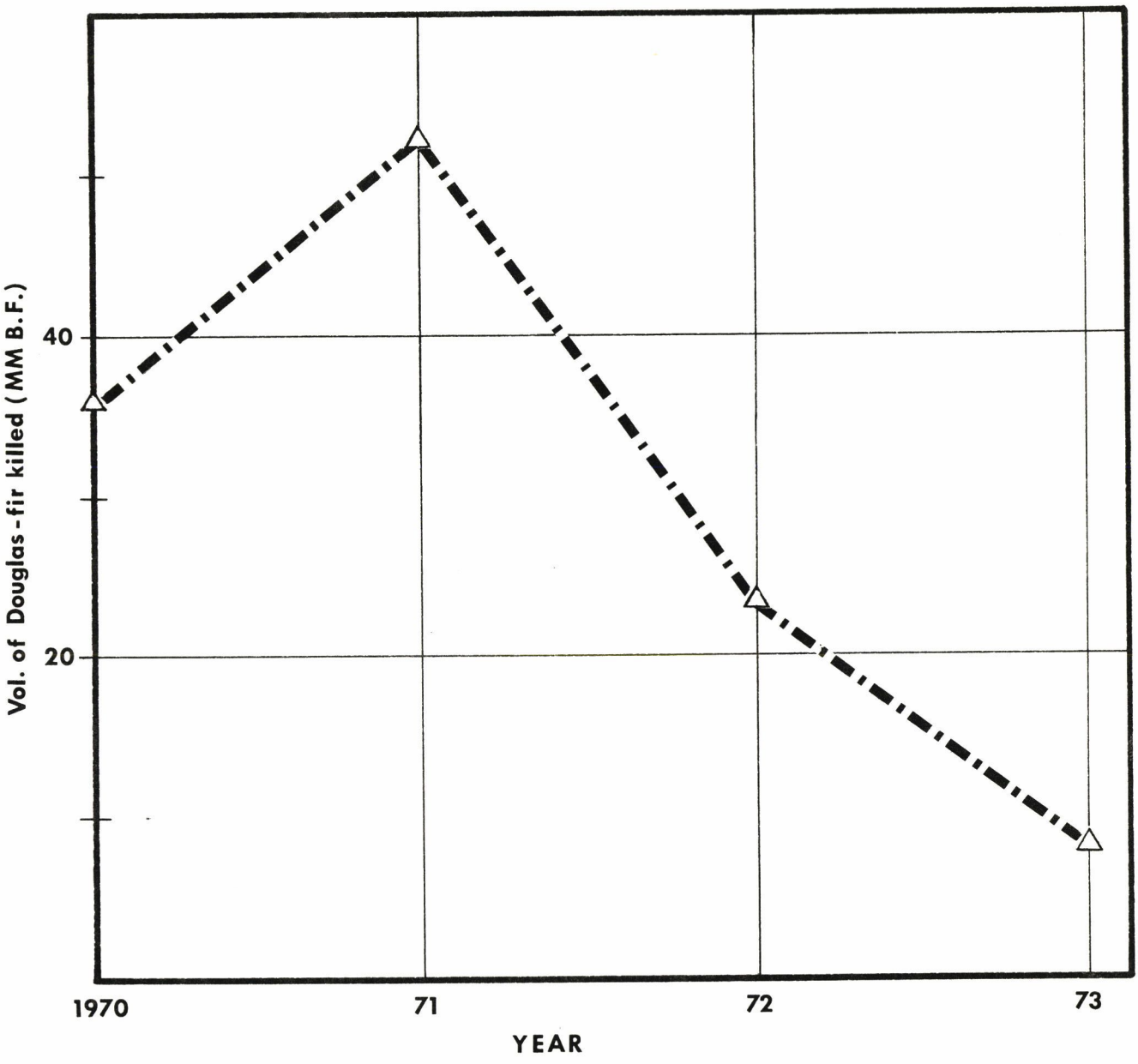



Figure 5 Volume of Douglas-fir killed by the Douglas-fir beetle from 1970 through 1973.

1974 as a result of the serious drought that occurred in 1973. With the increase in number of unsuccessfully attacked trees and the decrease in number of successfully attacked trees (Table 4), the size of infested groups decreased and became more widely scattered. Thus, successfully attacked trees became more difficult to locate for brood sampling.

Table 7.--Densitites of natural enemies occurring on bark samples, North Fork Clearwater River, 1971-1973.

| | | | Insect density per square foot of bark surface | | | |
|---|---|---|---|---|---|---|
| Year | Groups sampled | No. sampled | *Coeloides brunneri* | *Medetera aldrichii* | *Temnochilda chlorodia* | *Cleridae* |
| 1971 | 3 | 122 | 11.1 | 0.7 | 0.1 | 0.2 |
| 1972 | 11 | 182 | 13.0 | .2 | -- | .05 |
| 1973 | 15 | 242 | 5.0 | 1.03 | .29 | -- |

With the decrease in number of trees successfully attacked, a marked decrease must have occurred in the Douglas-fir beetle population throughout the infested area. Also the brood/parent ratio of 1:1 in 1971 and 1972 decreased to 0.82:1 in 1973 indicating a decreasing population. When the Douglas-fir beetles enter the fall or overwintering period with a brood to parent ratio of less than 1:1 as is here indicated, it will result in further brood reduction prior to beetle flight next May. This reduction will probably be caused by natural factors (physical) other than parasites and predators. With this pronounced reduction in brood occurring, we would expect the reduction in number of infested trees to coincide.

Four of the 30 ground truth plots selected by the PPSORT program overlapped pheromone test areas established by the Boyce Thompson Institute for Plant Research. Analysis of these plots showed that the 1973 attacked trees averaged 0.38 tree per acre compared to the survey average of 0.028 tree per acre. We might conclude that pheromone within these areas may have increased the number of 1973 attacks per acre although two of the four areas were in heavy outbreak type before pheromone introduction. Although these plots may not reflect the natural infestation, we feel that to eliminate them from the analysis would bias plot selection and would not be feasible with PPSORT sampling in estimating the variance correctly.

Surveys conducted during 1971-73 provided resource managers with data upon which to plan and carry out salvage logging. Table 8 shows respective landowners and salvage logging efforts through 1973.

Table 8.-- Salvage logging by respective land ownerships of bark beetle infested Douglas-fir, North Fork Clearwater River drainage, 1971-1973.

| Year | Volume salvage logged by ownership (bd. ft.) | | | | |
|---|---|---|---|---|---|
| | State of Idaho | National Forest | | Potlatch Corp. | Total |
| | | St. Joe (Palouse RD) | Clearwater (Canyon RD) | | |
| 1971 | 2,327,400 | 0 | 0 | 2,746,000 | 5,073,400 |
| 1972 | 6,870,000 | 1,805,000 | 1,200,000 | 10,071,000 | 19,886,000 |
| 1973 | 4,735,720 | 110,000 | 0 | 10,711,000 | 15,556,720 |
| Total | 13,873,120 | 1,915,000 | 1,200,000 | 23,528,000 | 40,516,120 |

## RECOMMENDATIONS

Based on our observations of this outbreak, we offer the following which might be helpful in management of stand to reduce and prevent losses caused by the Douglas-fir beetle:

1. Remove susceptible trees, i.e., windthrow, snow breakage, overmature, and those infested with root rot

2. Log or commercially thin Douglas-fir stands as they reach about 120 years of age

3. Salvage log infested trees promptly

4. Avoid extensive, even-aged, overmature stands where possible and practical.

## REFERENCES CITED

Ciesla, W. M., M. M. Furniss, M. D. McGregor, and W. E. Bousfield, 1971. Evaluation of Douglas-fir beetle infestations in the North Fork Clearwater River drainage, Idaho--1971. USDA, For. Serv. Division State and Priv. Forestry, Missoula, Mont., Rept. No. 71-46.

Evenden, J. C., 1952. Douglas-fir beetle infestation, Northern Rocky Mountain Region. USDA, ARS, Bureau of Entomology and Plant Quarantine. Forest Insect Lab., Coeur d'Alene, Idaho. 17 pp.

Furniss, M. M., 1962a. Infestation pattern of Douglas-fir beetle in standing and windthrow trees in southern Idaho. Jour. Econ. Ent. 55:486-491.

Furniss, M. M., 1962b. A circular punch for cutting samples of bark infested with beetles. Can. Entomol. 94:959-963.

Furniss, M. M., M. D. McGregor, M. W. Foiles, A. D. Partridge, and R. W. Williams, 1974. Factors associated with Douglas-fir beetle populations and damage in Northern Idaho. (In prep.)

McGregor, M. D.., W. E. Bousfield, and D. Almas, 1972. Evaluation of the Douglas-fir beetle infestation in the North Fork Clearwater River drainage, Idaho--1972. USDA, For. Serv., Division State and Priv. Forestry, Missoula, Mont. Rept. No. I-72-10.

McGregor, M. D., 1973. Survey of Douglas-fir beetle infestation using true-color photography. North Fork Clearwater River drainage, Idaho. Work plan.

Rudinsky, J. A., 1966. Host selection and invasion by the Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopkins, in coastal Douglas-fir forests. Can. Entomol. 98:93-111.

Stage, A. R., 1971. Sampling with probability proportional to size from a sorted list. USDA, For. Serv. Inter. For. and Range Expt. Sta., Ogden, Utah. Res. Paper INT-88.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1974—696-148/2